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Comparison of Isokinetic Muscular Strength of the Knee Joint according to the Ankle Joint Position

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Abstract

Objectives: The purpose of the study was to investigate the effect of the position of the ankle joint on the isokinetic muscular strength of the knee joint. **Methods/Statistical Analysis**: The subjects of this study were 20 young and healthy adult females who were applied at random ankle joint positions and underwent the flexion and extension of the knee joint. Isokinetic muscle strength was measured for each process at an angle speed of 60°/sec with CSMI. The comparison of knee muscle strength for each ankle position was conducted by a one-way ANOVA. Post hoc tests utilized LSD. **Findings**: When the knee joint was extension at a 40° plantar flexion, it showed a significant difference regarding the neutral position and the position of the 20° dorsiflexion ($p<.05$). Knee flexion did not show a significant difference depending on the position of the ankle joint ($p>.05$). The muscle strength rate of the knee joint showed a significant difference for the neutral position and the position of the 20° dorsiflexion at the position of a 40° plantar flexion ($p<.05$). **Improvements/Applications**: We propose that the position of plantar flexion was the most effective at expressing maximum muscle strength when doing an isokinetic knee extension exercise.

Keywords: Ankle, Isokinetic Exercise, Isokinetic Strength, Joint Angle, Knee

1. Introduction

Ankle joint is needed for our daily lives by maintaining correct postures and sustaining the body weight. It is also necessary for us to perform hard sports motions such as running and cornering the bending force at the sole area directly intervenes to the creation of ground reaction forces[1,2]. Among the ankle joint muscles, soleus muscle passed through a single joint while gastrocnemius was a two-joint muscle that was involved not only in the motions of dorsiflexion as well as that of knee joints[3]. Therefore, the gastrocnemius was affected by the knee joint position and posture in terms of anatomic structure and it demonstrated different muscular revelation depending on the length and tension of muscles in particular[4]. The angle of ankle joint varied depending on the height of the heel and affected to the strength of muscle[5]. In[6] reported that when a subject performed the squat posture with heel-less shoes or 5 cm high heeled shoes, the former showed high muscle activities in vastus lateralis while the latter resulted with high muscle activities in vastus medialis[6]. In addition, demonstrated that the inclination of a treadmill influenced the muscle activities of rectus femoris and tibialis anterior[7].

Although our knee joint, the biggest and most complicated joint was separated by the traction splint and tibia, it was supplemented by the functional articular surface. Even though a huge force was put on the two longest bones in our body, knee joint was well organized like one big axis that sustained the body weight. The knee joint was an important role at the locomotion. Among the knee joint muscles, quadriceps activated in times of deceleration and extension, while hamstrings cooperatively acted with the other muscles in times of flexion and other knee joint movements[8,9]. Isokinetic exercise was used to unveil the effect of various training methods such as combined

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exercise training and plyometric because this exercise had the advantages of leading muscular contraction within the ROM[10–12]. In[13–15] suggested Hamstrings/Quadriceps strength (H:Q) ratio that reflected the basic capacity of knees and the muscular balance[13–15]. H:Q ratio was expressed as contractibleness hamstrings and quadriceps strength and the ratio changed depending on the posture and speed of isokinetic muscular force inspection[16]. The higher imbalance of H:Q ratio among female athletes than their male counterparts was the reason for their susceptibility to the sports injury[17,18]. Furthermore, H:Q ratio was a useful index for the judgment of the prevention and recovery of the limb related injuries[19,20]. Nevertheless, domestic research effort put on to the H:Q ratio was very low and the importance of it was neglected in the interpretation process of isokinetic results[21].

Several previous studies reported to standardize the results of isokinetic strength for single joint. However, the muscular force resulted from the interaction of joint positions. Therefore, this research identified effect of position of ankle joint with maximum absolute muscular force and H:Q ratio.

2. Methods

2.1 Subjects

Research subjects were females who went to the 'S' university in South Korea. They agreed to the contract prior to the experiment and we selected among many candidates who applied. Participants consisted of total 22 people who used their right foot as their regular. Their physical status was as given in Table 1. Before the experiment, we had explained the purpose and process of our research to the participants as clearly as possible and let them read the terms of agreement. Exemption conditions included surgical experiences within 6 months in either nervous or muscular skeletal system, any type of damage in physical balance as well as sight and hearing, symptoms of dizziness or any kind of disability and any type of medical problems. There was none who were excluded before the actual test, however, 2 participants dropped out during the experiment as they experienced some severe muscle cramps.

2.2 Test Method

Maximum muscular force data were collected through isokinetic muscular joint evaluation and rehabilitation exercise system (CSML Humax Co. USA 2001). We conducted the experiment repetitively with a single group of participants. Subjects sat on the measuring chair and tied their body on it with the belt. In order to realize a safe joint velocity, we had set it to 60°/sec using rehabilitation exercise system (CSMI) and measured their maximum flexion and extension range of knee joint [Figure 1]. Experiment postures including neutral position, dorsiflexion 20° and plantar flexion 40° were proceeded in a randomly manner [Figure 2]. And to maintain dorsiflexion and plantar flexion posture, muscular taping was used. To measure the maximum muscular strength of flexion and extension of the knee joints from each posture, bending and extending were performed 5 times respectively. After measuring the maximum muscular force of the knee joints flexion and extension, we divided the maximum flexion strength with the extension and compared the muscular force ratio.

Table 1. The general physical status of the research participant (n = 22)

Category	Average Value
Age	19.40 ± 1.54
Height	161.20 ± 4.25
Weight	55.80 ± 7.98
Average ± Std. deviation	

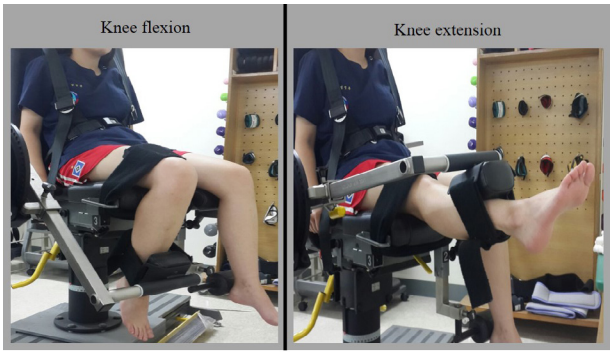

Figure 1. Maximum range of knee joint.

2.2 Data analysis

The results were statistically processed with SPSS ver 18.0 for Windows. We compared the maximum muscular force and examined the ratio of the maximum isokinetic muscular force among the neutral, dorsiflexion 20° and plantar flexion 40° posture using one-way ANOVA analysis followed by LSD post hoc test. Significance level of all statistics were set as $p<.05$.

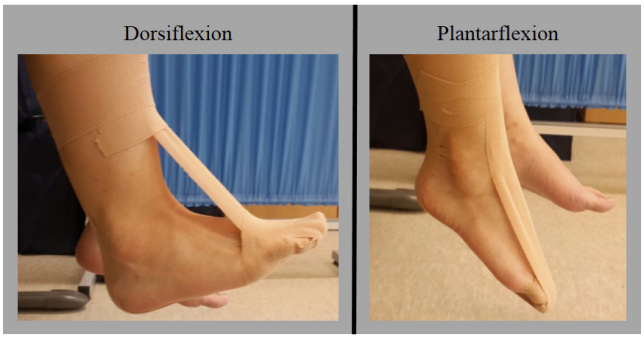

Figure 2. Maintain dorsiflexion and plantar flexion posture.

3. Results

The maximal muscle force of flexor in the neutral position was 44.95±9.95 Nm while that of the extensor was 98.15±14.43Nm. In Plantar flexion 40°, the maximal muscle force of flexor was 43.85±11.75 Nm and the extensor was 110.10±15.62 Nm. In dorsiflexion 20°, the flexor was 43.05±9.59 Nm and the extensor was 99.95±14.57 Nm [Table 2]. The comparison of the muscular force was significant difference among neutral, plantar flexion and dorsiflexion position for the knee extension ($p<0.05$). In the post-hoc test, the plantar flexion position was shown the highest muscular force. In contrast, knee joint flexion did not show any significant difference in the muscular force among the different the ankle joint positions. The ratio of muscular force in the neutral position was 45.45±4.69% while that of the dorsiflexion 20° and plantar flexion 40° was 39.38±6.16% and 42.74±4.69% respectively [Figure 3]. The ratio was highest in the neutral position and the plantar flexion followed by dorsiflexion. Difference in the ratio among those three positions was statistically significant ($p<0.05$).

Table 2. Comparison muscular force and ratio among the positions

	Neutral	**Plantar flexion**	**Dorsiflexion**	*F*
Knee flexion	44.95 ± 9.94	43.85 ± 11.75	43.05 ± 9.59	0.16
Knee extension	98.15 ± 14.43	110.10 ± 15.62	99.95 ± 14.5	3.74*
H:Q ratio (%)	45.45 ± 4.69	39.38 ± 6.16	42.74 ± 4.69	6.79*
Average ± Std. deviation, *; p<.05.				

4. Discussion

In this study, we have measured the maximum isokinetic muscular force of bending and extending of knee joint with the neutral, dorsiflexion 20° and plantar flexion 40° position and compared the isokinetic muscular force and ratio of the flexor and extensor using CSMI. As a result, the absolute muscular force was the biggest with the dorsiflexion position and the knee extended. The isokinetic muscular force ratio was the biggest in the neutral position followed by plantar flexion and dorsiflexion position.

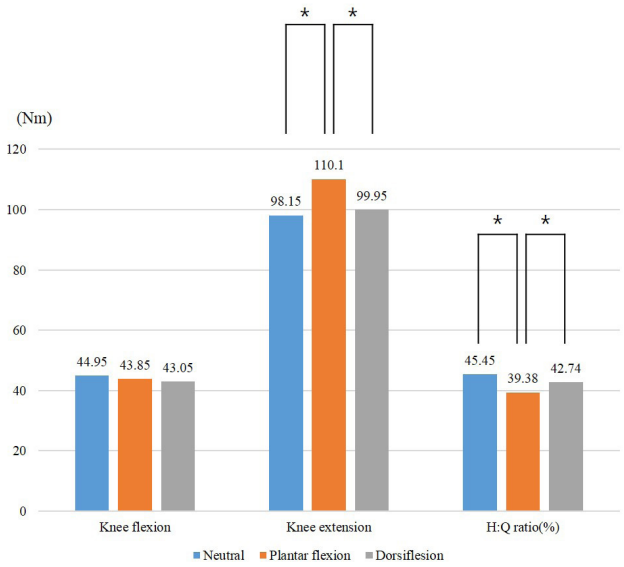

Figure 3. Results of post-hoc analysis.

In this study, in the case of knee joints extension, there was a significant difference among the different ankle joint postures. In times of the dorsiflexion 40°, influence of gastrocnemius muscle was minimized and the hamstrings muscle was relaxed. Therefore, the body was straightened and impact of iliac muscle was reduced. This position was a concentrated resistance onto the quadrate muscle of thigh[22]. However[5] reported that there was no difference in the muscular activation of the rectus femoris and vastus medialis, vastus lateralis among ankle position[5]. The ankle position of previous study was dorsiflexion 20°. We suggested that the reason why the knee extension show no significant value in the dorsiflexion 20° was because the gastrocnemius interferes the plantar flexion so that the absolute muscular force was measured lower than the actual value as mentioned in Kang's report

in 2000[23]. Gastrocnemius was an agnostic muscle for the dorsiflexion and an accessory muscle for knee flexion. According to[24] the muscular activation of gastrocnemius was reduced at the position of knee flexion[24].

The H:Q ratio of knee joint was the most often used for the evaluation of muscular balance because the antagonistic muscle cooperated with the agnostic muscle maintaining the general balance[25]. The H:Q ratio was low in times of isokinetic contraction exercise, traumatic damage could occur with higher possibility[26] and muscular pain as well as the destruction of ligament or cartilage became more likely to occur with 60% or lower H:Q ratio[27]. In addition, the H:Q ratio demonstrated closer to the reality the relationship between the concentric contraction and eccentric contraction during knee flexion and extension[28]. Furthermore,[17] stated in his comparative study about the sports injury probability of the male and female that the knee joint related sports injuries that occurred among female athletes was mainly caused by the ratio between the flexion and extension force[17]. Therefore, we investigated the H:Q ratio as one of the most important measurement factor and also limited the participants to the female. The standard value of H:Q ration in the previous studies were 46.64±7.33[29]. The H:Q ratio of this study was 45.45±4.69% in neutral posture, 42.74±4.69% in dorsiflexion 20° and the lowest 39.38±6.16% in plantar flexion 40°. The H:Q ratio was affected by weakness of hamstring muscle compared with the quadriceps muscle[30]. From our study it has been proven that the dorsiflexion exercise was effective in the reduction of H:Q ratio and the result was expected to contribute to prevent the reduction of knee joint extension muscle force that was caused by aging and further symmetrically develop the muscles surrounding the knee joint.

The results from our study showed the relationship between the ankle position and knee muscle force. This was expected to be used for the enhancement of muscular function of patients who suffered from the knee joint related illness in practice. However, we cannot deny the fact that the study is limited to a certain age group and that it excludes the original muscle amount, fat amount and ratio and the daily exercise habits. Following researches should also include the measurement of the aforementioned body compositions and extend its concern from the current ankle joint angle to the coxalgic pelvis and bodily status as well.

5. Conclusion

The purpose of this research was to compare and figured out if the ankle joint's posture affects the absolute muscular force of knee joint flexion and extension. In conclusion, dorsiflexion 40° was effective for the creation of high maximum muscular force and the ration between the knee flexion and extension muscle was biggest in the neutral position, followed by plantar flexion 20° and dorsi flexion 40° posture. As for the knee extension enhancement exercises, dorsiflexion 40° was much more effective than the neutral and plantar flexion posture. We believe the results of our research would be used for the patients suffering from the knee joint related diseases to go through much more effective knee joint exercises and also for the doctors to evaluate the improvement of their patients more effectively in the field.

6. References

1. Miyazaki S, Yamamoto S. Moment acting at the me tatarsophalangeal joints during normal barefoot level walking. Gait and Posture. 1993; 1(3):133–40.
2. Gyu KT, Chul PJ. Relationship between balance and isokinetic strength of ankle joint by playing position of elite female field hockey players. Indian Journal of Science and Technology. 2015; 8(19):1–6.
3. Helenm J, Hislo P, Jacqueline M. Muscle testing. 6th ed. Philadelphia: W. B. Saunders Co; 1995. p. 251–67.
4. Walmsley RP, Christopher S. A comparative study of the torque genetated by the shoulder internal and external rotator muscles in different positions and various speeds. Journal of Orthopaedic Sports Physio Therapy. 1987; 9(6):217–22.
5. Yeo SS, Kwon JW, Kim CS. The effects of ankle joint angle on knee extensor electromyographic activity. Journal of Korean Society Physical Medicine. 2009; 4(1):15–21.
6. Lee HJ, Kim SJ, Kim SJ, Kim HJ, Park BR, Park SY. Effect on the lower extremity muscle activity according to the heel height and wedge position. Journal of Rebailitation Engineering and Assistive Technology Society of Korea. 2014; 8(4):291–7.
7. Kim SG. Effect of treadmill gradient training on lower limb muscle activity in chronic stroke patient. Journal of the Korea Academia-Industrial Cooperation Society. 2012; 13(1):220–6.
8. Kim SK, Bin SI, Kim CJ. The usefulness of measuring knee joint isokinetic parameters in patients with anterior cruci-

ate ligament injury. Korean Association of Medical Journal Editors. 1997; 15(2):225–34.
9. Jin OS, Goo KJ, Kil LS. Relationship between isokinetic strengths, subjective knee scores, and functional performance after ACL reconstruction. Indian Journal of Science and Technology. 2015; 8(S9):390–6.
10. Choi HH, Lee DJ, Yu YK. The effect of lower limb training program on maximum muscular strength of lower limb and physical fitness of university soccer player. KJGD. 2013; 21(2):83–9.
11. Marcovic G. Does plyometric training improve verti cal jump height a meta-analytical review. British Journal of Sports Medicine. 2007; 41(6):349–55.
12. Park JS, Park SY. Effects of isokinetic strength and foot-pressure with and without to injury of knee Joint. KJGD. 2013; 21(3):205–10.
13. Grace TG, Sweetser ER, Nelson MA, Ydens LR, Skipper BJ. Isokinetic muscle imbalane and knee joint injuries: A prospective blind study. Journal of Bone Joint Surgery American. 1984; 66(5):734–40.
14. Agaard P, Simonsen EB, Trolle M, Bangsbo J, Klausen K. Isokinetic hamstring/quadriceps strength ratio: Influence from joint angular velocity, gravity correction and contraction mode. Acta Physilogica Scandiavia. 1995; 154(4):421–7.
15. Holmes JR, Alderink GJ. Isokinetic strength characte ristics of the quadriceps femoris and hamstrings muscles in high school students. Physical Therapy. 1984; 64(6):914–8.
16. Shin CH. Isokinetic strength of quadriceps and ham string, hamstrings/quadriceps ratios in ellite sports. Korean Journal of Physical Anthropolgy. 2008; 21(4):351–60.
17. Hewett TE, Ford KR, Myer GD, Wanstrath K, Scheper M. Gender differences in hip adduction motion and torque during a single leg agility maneuver. Journal of Orthooptics Research. 2006; 24(3):416–21.
18. Song JE. Comparative study between the knee joint and muscular strength among Korean dancer, ballet dancer and normal person. Journal of Korean Society of Dance. 2008; 16:1–11.
19. Cho HC, Roh DS. A study on injury prevention and teaching methods in boxing by the characteristics of leg muscular strength of different angular velocity in amateur boxing athletes. Journal of Korean Society for the Study of Physical Education. 2013; 18(2):275–83.
20. Cress NM, Peters KS, Chandler JM. Eccentric and concentric force velocity relationship of the quadriceps femoris muscle. Journal of Orthopaedic and Sports Physical Therapy. 1992; 16(2):82–6.
21. Jeon TW, Shin HJ, Kim YW, Park ST. Development of low-extremity isokinetic strength normative database for adults 20-30. Kinesiology. 2011; 13(4):19–27.
22. Yoo WK, Lee CH, Lee HJ. Effects of a combined posture of the lower extremity on activity of the vastus medialis oblique muscle and vastus lateralis muscle during static squat exercise. Physical Therapy Korea. 2004; 11(3):1–9.
23. Kang SS, Kwon TW. Isokinetic evaluation for each optimal angle on peak torque of the knee and ankle joints for the eltite jumping players in athletic sports. Journal of The Korean Society of Sports Science. 2000; 9(2):769–78.
24. Adamantios A, Kiros K, Savvas S, Gaspar MK, Gianpiero D, Gert-Peter B. Effect of different ankle and knee joint positions on gastrocnemius medialis fascicle length and EMG activity during isometric plantar flexion. J Biomech. 2006; 39(10):1891–902.
25. Coombs R, Garbutt G. Developments in the use of the hamstring/quadriceps ratio for the assessment of muscle balance. Journal of Sports Science Medical. 2002; 1(3):56–62.
26. Soderman K, Alfredson H, Pietila T, Werner S. Risk factors for leg injuries in female soccer players: A prospective investigation during one out-door season. Knee Surg Sports Traumatol Arthrosc. 2001; 9(5):313–21.
27. Burkett LN. Causative fators in hamstring strains. Med Sci sports. 1970; 2(1):39–42.
28. Han TR, Kim IS, Kim JH, Kim YS. Normative data of functional hamstring/quadriceps ratios by age based on isokinetic exercise testing. J Korean Acad Rehabil Med. 2003; 27(5):764–73.
29. Yu CS, Chang SK. The isokinetic evaluation of knee extensors and flexors in the normal subjects for those twenties. Journal of Korean Society Physical Therapy. 2013; 25(4):167–73.
30. Park MH. Changes of quadriceps and hamstring strength ratio in women of different ages. Journal of Korean Society Physical Therapy. 2006; 13(3):75–83.